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Oxygen fugacity, temperature reproducibility, and H_2O contents of nominally anhydrous piston-cylinder experiments using graphite capsules

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Abstract

The Pt-graphite double-capsule technique is a very commonly used method in high-temperature, high-pressure experimental petrology, particularly for anhydrous experiments relevant to primitive basaltic magmas and mantle melting. We have performed a series of experiments that place better constraints on the range of oxygen fugacity imposed by this capsule material, on the Fe^{3+}/Fe^{2+} ratios in experimentally produced melts and minerals, and on the temperature reproducibility in Pt-graphite capsules. Oxygen fugacity in our piston-cylinder experiments using Pt-graphite capsules is CCO-0.7 (IW+1.5, QFM-2.2) at 1.5 GPa and 1360 °C. Comparison with other estimates and thermodynamic calculations indicate that a value of CCO-0.8 ± 0.3 can be used as a first approximation at least over the *P-T* range relevant for MORB and OIB magma generation (0.5–3.0 GPa, 1100–1500 °C). Under those conditions, the amount of Fe^{3+} in silicate phases (pyroxenes, olivine, glass) and spinel is negligible ($Fe^{3+}/\Sigma Fe < 0.05$) and would not significantly affect thermodynamic properties. Significantly higher values of f_{O_2} cannot be achieved using Pt-graphite or graphite only capsules, but f_{O_2} can be tuned to lower values by using small pieces of PtFe alloys. The potential range of f_{O_2} that can be reached in graphite or Pt-graphite capsules is CCO to CCO-4. Temperature reproducibility in piston-cylinder experiments has been examined and can be as low as ±10 °C. Finally, unless capsules are dried overnight at 400 °C before the experiment, small amounts of H_2O are always present in nominally dry experiments. These small amounts of H_2O should not, however, significantly change phase relations.

Keywords: Experimental petrology, oxygen fugacity, piston-cylinder, graphite, phase equilibria, reproducibility, Mössbauer spectroscopy, pyroxenes